APPENDIX A

MODELING RUN DETAILS

The following details the model simulation runs for the Muscoy OU model: Table A1 provides a summary of the transient-state calibration runs.

Several simulations were conducted during the particle tracking phase of subtask 1.4:

- Run 42A - This run was the no action scenario, and was run for the complete simulation period of 35 years. This was the initial run of the transient-state model to be used in conjunction with Muscoy OU task analysis. It is the same MODFLOW run as Newmark 37A. The PATH3D© post processing files used imaginary particle locations in the northeast area of the active model area to reflect the emphasis toward analysis of suspected source areas. Introduced particles did not travel from west to east through the Shandin Hills and Wiggins Hill Gap (SWG).

  This configuration of the model (due to groundwater gradient) did not allow for flow from the Cajon Landfill to the Newmark plume. No changes were made to the model for this simulation.

- Run 43A - This run included revised no-flow boundary conditions to the west of Shandin Hills, accomplished by extending the no-flow boundary 820 feet further. Within the model, the boundary between bedrock and the aquifer can be moved in increments of one grid cell, 820 feet; bedrock is considered as a region of no-flow. This analysis tested the theory that extra no-flow area would mound water and force the gradient between Wiggins and Shandin Hills, effectively changing groundwater flow toward the east. The extra no-flow area, it was reasoned, could be caused by vertical undulations in the unknown bedrock topography. The anticipated result did not occur. The changes made to this run will not be incorporated into the model.

- Run 43B - This run included revised no-flow boundary conditions to the west of Shandin Hills by the extension of the no flow boundary 820 feet further than Run 43A. This extended the theory behind Run 43A to a worst case scenario. There were no radical changes in model results, and the model still did not show an eastward gradient. It is concluded that bedrock geometry is regulating model solution in the SWG. The changes made to this run will not continue to be incorporated into the model.

- Run 44A - This simulation investigated equilibration of the transient-state model in response to adjusted initial groundwater elevations. This was conducted to see if the effect would propagate the gradient in the SWG in the observed direction. Initial heads in the Newmark well area were assigned known values equal to data collected during the field phase of the Newmark RI/FS. The model dampened the effects introduced in four to eight time steps, representing a time frame of one to two years. Real world events like step functions introduced to the area are known to cause similar behavior. This run indicates that initial heads do not grossly affect the model solution in the Newmark wellfield area and the SWG. The changes made to this run will not continue to be incorporated into the model.

Table A1

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
42A	1) Particle tracking used for potential contaminant source tracking - investigation of single point source theory. 2) To establish whether the Cajon Landfill lies within the path of potential sources of the Newmark and Muscoy plumes.	1) Used input files from calibrated Newmark O.U. transient-state model (Run 37A). Renamed 42A for Muscoy investigation. 2) Conducted particle tracking study w/ Path3D.	1) Simulation for 42A converged with 0.00% water balance discrepancy. 2) Current configuration of model does not allow for flow from the Cajon Landfill to the Newmark plume due to the groundwater gradient in the gap between Shandin and Wiggins Hills (SWG).
43A,B	1) Study the effect on flow direction in SWG based on no-flow boundary effects west of Shandin Hills.	1) 42A input files modified to include no-flow conditions in cells 23,14 and 23,15 for run 43B and 23,15 for run 43A. 2) Conducted particle tracking study w/ Path3D.	1) Simulations 43A and 43B converged with 0.00% and 0.00% water balance discrepancies, respectively. 2) Extension of no-flow conditions further to west of Shandin Hills had limited effect on SWG gradient.
44A	1) Study the damping effect to initial heads in model to discount effect of initial heads to SWG gradient.	1) Input files from run 42A were modified to include new initial head data from Newmark RI/FS field data for the Newmark wellfield area. 2) Conducted particle tracking study w/ Path3D.	1) Simulation 44A converged with 0.00% water balance discrepancy. 2) Effects introduced by differences in initial head were dampened out in the simulation in approximately 2 years.
45A,B	1) Increase active flow area between Wiggins and Shandin Hills in order to redistribute water in this area to the south and west. 2) Reduce boundary effects in the SWG due to small active area.	1) Input files from run 42A were modified to include 10 previously inactive cells in area of "SWG". 2) Bedrock, conductivity, and other data were extrapolated or interpolated for the newly active cells. 3) Conducted particle tracking study w/ Path3D. 4) Run 45B was conducted in order to change the secondary storage factor from that included in Run 45A.	1) Simulations 45A and 45B converged with 0.00% and 0.00% water balance discrepancies, respectively. 2) Cells directly south of Wiggins hill went dry early in scenario. 3) It was observed that the change of secondary storage factor had no detrimental effects to the model.
46A	Not run		
47A	Not run		

Table A1 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
49A	1) This run was conducted as baseline for comparison.	1) Used input files from run 42A Muscoy investigation. 2) Modified BAS file to run for only 20 stress periods (five years). Modified secondary storage factor in BCF file.	1) Simulation for 49A converged with 0.01% water balance discrepancy. 2) Lower level of confidence in model calibration due to this run. 3) The changes made to this run will be incorporated in future models.
49B	1) Achieve a more even distribution of water entering the model through the northwestern boundary.	1) Used input files from run 49A. 2) Modified GHB file.	1) Simulation 49B converged with 0.00% water balance discrepancy. 2) Very limited observable effect on model solution: reduced head discrepancies observed across Loma Linda Fault at western boundary of model. 3) The changes made to this run will be incorporated in future models.
49C	1) Reduction in specific yield value to reduce over-abundance of water in Muscoy plume area.	1) Used input files from run 49B. 2) Modified specific yield from .15 to .05 globally in BCF file.	1) Simulation 49C converged with 0.00% water balance discrepancy. 2) Had no observable effect on model solution. 3) The changes made to this run will not be incorporated in future models.
49D	1) Redistribute water within the model by changing hydraulic conductivity values.	1) Used input files from run 49B. 2) Modified hydraulic conductivity values in BCF file to increase values in Muscoy plume area and decrease values in area west of Shandin Hills.	1) Simulation 49D converged with 0.00% water balance discrepancy. 2) Had very limited effect on model solution. Conclusion: Make more substantial changes to get an observable effect. 3) The changes made to this run will not be incorporated in future models.

Table A1 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
49E	1) Redistribute water within the model by changing hydraulic conductivity values.	1) Used input files from run 49D. 2) Increased previously modified hydraulic conductivity values in BCF file by 1 and 2 orders of magnitude in Muscoy plume area (still within credible limits).	1) Simulation 49E converged with 0.00% water balance discrepancy. 2) Had noticeable effect on model solution. Results indicate objective has value but needs further investigation.
50	1) This is a Newmark OU run and will not be discussed here.		
51A	1) Resolve problems associated with excessively high and low head values along San Jacinto Fault. 2) Further define degree of calibration of model.	1) 49B input files were modified for initial head, river bottom elevations, and river stage elevations. 2) Increased time span of analysis back to 35 years. 3) Conducted particle tracking with PATH3D©	1) Simulation converged with 0.00% water balance discrepancy. 2) Model has more predictable behavior along boundary. 3) These changes will be incorporated into future versions of the model.
51B	1) Establish predicted drawdowns in head from the Perris Street well in order to correlate to observed values. 2) Further define degree of calibration of model.	1) Input files from run 51A were modified to include the Perris Street well pumping @ 1,500 gpm.	1) Simulation converged with 0.01% water balance discrepancy. 2) Predicted drawdown from the model is less than, but the same order of magnitude as observed value from aquifer pumping test. 3) These changes will not be incorporated into future versions of the model.

Table A1 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
51C	1) Establish predicted drawdowns in head from the Perris Street well in order to correlate to observed values. 2) Further define degree of calibration of model.	1) Input files from run 51A were modified to include the Perris Street well pumping @ 3,000 gpm.	1) Simulation converged with 0.01% water balance discrepancy. 2) Predicted drawdown from the model is less than, but the same order of magnitude as observed value from aquifer pumping test. 3) These changes will not be incorporated into future versions of the model.
51D	1) Establish predicted drawdowns in head from the Perris Street well in order to correlate to observed values. 2) Further define degree of calibration of model.	1) Input files from run 51A were modified to include the Perris Street well pumping @ 4,000 gpm.	1) Simulation converged with 0.01% water balance discrepancy. 2) Predicted drawdown from the model is less than, but the same order of magnitude as observed value from aquifer pumping test. 3) These changes will not be incorporated into future versions of the model.
52A	1) Evaluate preliminary extraction well placement and extraction volume for model responses.	1) Input files from run 51A were modified to include five extraction wells pumping @ 2,000 gpm each.	1) Simulation converged with 0.00% water balance discrepancy. 2) Most of the introduced imaginary particles were removed except for those near the San Jacinto Fault boundary. 3) These changes will not be incorporated into future versions of the model.

Table A1 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
52B	1) Evaluate preliminary extraction well placement and extraction volume for model responses.	1) Input files from run 52B were modified to include three extraction wells pumping @ 2,000 gpm each.	1) Simulation converged with 0.00% water balance discrepancy. 2) Most of the introduced imaginary particles were removed except for those near the San Jacinto Fault boundary. 3) These changes will not be incorporated into future versions of the model.
52C	1) Evaluate preliminary extraction well placement and extraction volume for model responses.	1) Input files from run 52C were modified to include one extraction well pumping @ 2,000 gpm and 2 extraction wells pumping @ at 1,000 gpm each.	1) Simulation converged with 0.00% water balance discrepancy. 2) Most of the introduced imaginary particles were removed except for those near the San Jacinto Fault boundary. 3) These changes will not be incorporated into future versions of the model.
53A	1) Evaluate preliminary extraction well placement and injection well placement for model responses.	1) Input files from run 51D were modified to include 4 injections wells pumping @ 1,000 gpm.	1) Simulation converged with 0.00% water balance discrepancy. 2) Preliminary results are unsatisfactory. 3) These changes will not be incorporated into future versions of the model.
54A	1) Evaluate preliminary extraction well placement and injection well placement for model responses.	1) Input files from run 51D were modified to include 4 injection wells pumping @ 1,000 gpm.	1) Simulation converged with 0.00% water balance discrepancy. 2) Preliminary results are unsatisfactory. 3) These changes will not be incocporated into future versions of the model.

Table A1 (Cont'd.)

SUMMARY OF TRANSIENT-STATE CALIBRATION RUNS FOR MUSCOY OU
(SWG = Shandin Hills - Wiggins Hill Gap, a key flow area in the model)

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
55A	1) Remove revisions made to run 49B, but keep revisions from run 51A.	1) Input files from run 49A were modified to include revisions to run 51A. These revisions included initial head, river storage, and river bottom elevations.	1) Simulation converged with 0.00% water balance discrepancy. 2) Model has more predictable behavior along San Jacinto fault boundary. 3) The changes made to this run will be incorporated in future models.

- Run 45A - This run investigated changing currently inactive cells to active cells in the model area on the north and west sides of Shandin Hills and the south side of Wiggins Hill. This decision was based on the cell size relative to the SWG, such that the new active area was increased by 66% (5 model cells in width versus 3 in previous analyses). It was postulated the model would react by redistributing water in these areas between the two hills to more realistic lower levels due to the larger area for water to flow through. This was also done to try to minimize boundary effects.

  During this simulation some model cells went dry (see Run 45B), and detailed analysis of the run was not continued. The changes made to this run will not continue to be incorporated into the model.

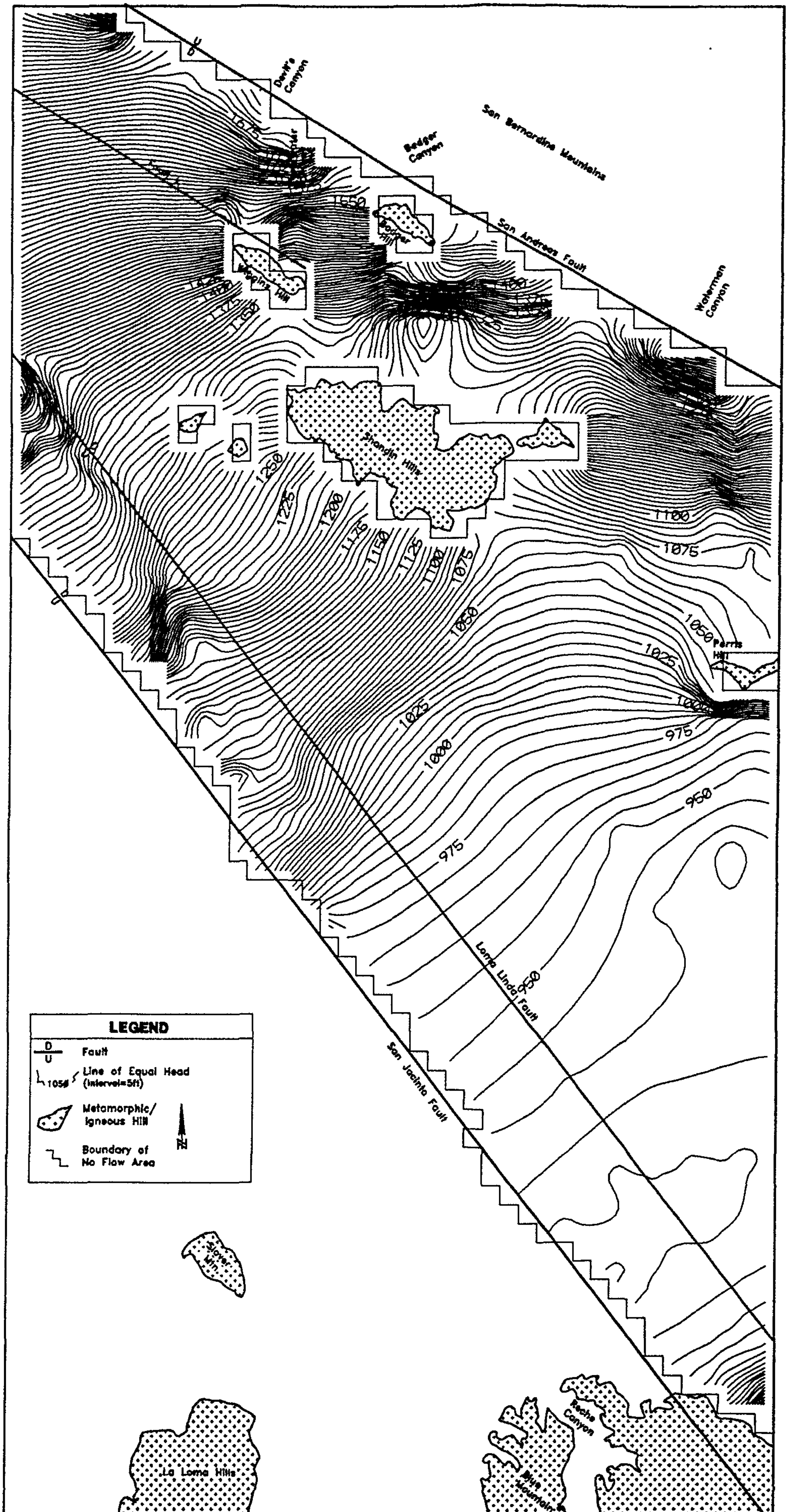
- Run 45B - The secondary storage factor for cells in the second layer were set equal to the aquifer specific yield. Prior to this run, the secondary storage factor was set equal to the storage coefficient. The use of the storage coefficient appeared to have little affect in the previous runs focusing on the Newmark OU. Use in the future of secondary storage may make the model less stable; but, no stability decrease has thus far been noted.

  The primary storage factor is used by MODFLOW when the second layer cells are completely saturated. This value should be the storage coefficient. The secondary storage coefficient is used by MODFLOW when the second layer cells are not completely saturated, as in the case where layer one goes dry. These changes were made to improve model accuracy in areas where cells go dry.

  The following results for this run were noted: the global change of the secondary storage factor had insignificant results and the two cells that were activated below Wiggins Hill both went dry apparently due to the model "shadow" effect of the hill. The shadow effect is simply the result of a local no-flow feature, such as a bedrock outcrop, which groundwater must flow around. In the lee, or shadow, there may be less water than expected from a larger, but more generic view. The small increase in model size did not significantly affect solution time. All analyses performed after this have incorporated the modification to secondary storage factor, but not the modifications to model active area.

Several simulations were conducted during the calibration verification/validation phase of subtask 1.4:

- Run 49A - This simulation was run for the five year period from 1986-1991 as a baseline for comparison of various calibration scenarios and to predict values of head for initial hydrographs of wells in the Muscoy plume region to compare with measured head values for the same time period. A head contour map for layer 2 is shown in Figure A1. This run indicated the correlation between observed and predicted head values in the Muscoy plume area was not as strong as it had been during earlier (Newmark area focused) model calibration. Changes made in this run included reduction of the overall time period which the model was run (5 years versus 35 years) and modification to the secondary storage factor value (see Run 45B). The changes made to this run will continue to be incorporated in the model.



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NEWMARK GROUNDWATER SUPERFUND SITE, MUSCOY OPERABLE UNIT RI/FS REPORT

FIGURE A1
October 1990 Water Elevations for Lower Aquifer Estimated by Transient-State Flow Model 55A

- Run 49B - This simulation investigated the effects of groundwater flux entering the model on the western boundary. A principal reason for this run was to achieve a component of eastward flow in the model to match the observed data. The head values used in the general head boundary conditions were modified to achieve a more even distribution of water across this surface. Due to discoveries made during the calibration process, the changes made to this run will not continue to be incorporated in the model. This model has been superceded by Run 55A.

- Run 49C - This simulation was conducted to investigate the effect of variation of the specific yield value on the storage of water in the area of the Muscoy plume. The purpose of this run was to cause the model head values to match the observable decrease in heads over time. The changes made to the model incorporated the lower reasonable limit for specific yield, but had very limited effects on the model solution. The results of this run did not produce the needed decrease in the overall storage. The changes made to this run will not be incorporated into the model.

- Run 49D - Local hydraulic conductivity values west of the Shandin Hills and within the Muscoy plume were varied to study the effect of redistribution of water within that portion of the model. It was anticipated that by redistributing the water, regional heads (being predicted by the model as too high) might be lowered. This run did not produce the desired effect due to the limited changes made to the conductivity values in the range of 20 to 60 ft/day. The changes made to this run will not continue to be incorporated into the model.

- Run 49E - This run used order-of-magnitude increases in the conductivity values in specific model areas in order to further explore the theory regarding the redistribution of water. Heads decreased in the upgradient area of the model and increased downgradient. Transmissivity values in the southeastern portion of the model will also need to be adjusted to redistribute water to the south.

  Hydrographs for the area to the southeast indicate areas of water deficiency (predicted head values are low). This indicates that the conceptual redistribution of water within the model is still a viable option and needs to be investigated more thoroughly. However, the decreasing head trend in this area is still not being predicted. The changes made to this run will not continue to be incorporated into the model, although the underlying concept is still valid.

The following preliminary modeling efforts included particle tracking and extraction scenarios to evaluate model responses from pumping at the leading edge of the Muscoy plume.

- Run 51A - This simulation investigated and remediated problems with excessively high and low head values along the San Jacinto Fault. Initial head values, river bottom, and river stage elevations were modified in order to moderate these head fluctuations to reasonable values. The changes made to this run will continue to be incorporated into the model. This simulation was run for 35 years.

- Run 51B - Using Run 51A as a base case, this run incorporated pumping 1,500 gpm from the Perris Street well in order to correlate predicted drawdown to observed phenomena.

  The changes made to this run will not continue to be incorporated into the model.

- Run 51C - Using the same rationale as Run 51B, this run incorporated pumping of 3,000 gpm from the Perris Street well. The changes made to this run will not continue to be incorporated into the model.

- Run 51D - Using the same rationale as Run 51B, this run incorporated pumping of 4,000 gpm from the Perris Street well. The changes made to this run will not continue to be incorporated into the model.

- Run 52A - Using Run 51A as a base case, this run incorporated 5 extraction wells pumping 2,000 gpm each in order to gain familiarity to the extraction volumes needed to achieve capture of all introduced imaginary particles in the Muscoy plume. Modifications will not continue to be incorporated into the model.

- Run 52B - Using modification of Run 52A, this run further investigated the extraction volumes needed to capture all introduced particles. This run incorporated 3 wells @ 2,000 each.

- Run 52C - Using 52B, this run incorporated 1 well @ 2,000 gpm, 2 wells @ 1,000 gpm each. A head contour map for layer 2 is shown in Figure A2.

- Run 53A - Preliminary injection and extraction scenario using Run 52C. Results will not be discussed here.

- Run 54A - Preliminary injection and extraction scenario using Run 52C. Results will not be discussed here.

- Run 55A - This run used input files from Run 49A as source files. It was discovered during model prediction efforts that the enhancements made to Run 49B did not achieve a refinement in calibration and therefore will be discarded. Modifications to this run included model refinements made in Run 51A. These include modifications to initial head, river stage, and river bottom elevations. Results from this run and Run 51A indicate that the general head boundary conditions are more important in the model solution than earlier believed. The water levels in the northwest portion of the model are somewhat impervious to small changes in the general head boundary conditions; however, the water introduced or removed due to these changes appears to have much more significant effects to the southeast portion, Layer 2 of the model. In Run 49B, small changes in the general head boundary conditions along the J=1, I=17-28 NW boundary of the model produced 50 foot head increases in the southeast portion of the model where the head predicted was already higher than observed; thus, this represented a larger deviation from calibration. Due to the newfound sensitivities to variance in the general head boundaries, it is suggested that model fluxes along boundaries be reevaluated during any future calibration.

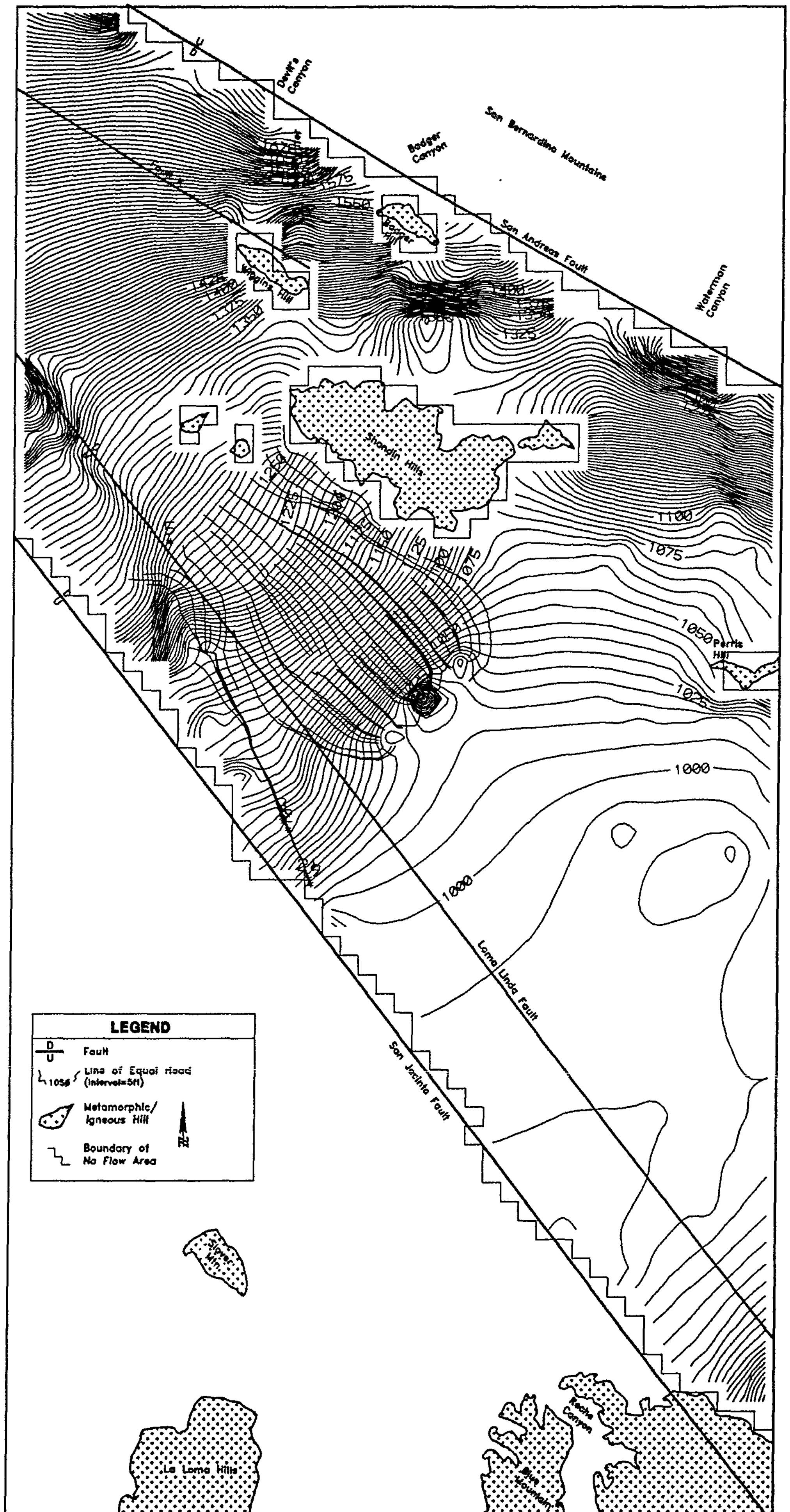

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FIGURE A2

October 2020 Water Elevations for Lower Aquifer Estimated by Transient-State Flow Model 52C

SCALE IN FEET

APPENDIX B

MODELING RECOMMENDATIONS

The following recommended general and specific actions should improve the performance of the model and increase the confidence in its outputs.

B.1 GENERAL ACTIONS

G1: Create a Formal Data Base.

At present, the raw and processed field data (potential and actual model input) have been cataloged, filed and accessible. Under this effort, the data descriptors would be assembled in a computer data base, flagged as to suitability, and a record of use or non-use in the model recorded. Parameters such as bedrock depth, would be contoured using geologic/hydrogeologic input, and data points (elevations, as well as "deeper than" data) noted on the map.

G2: Perform a Comprehensive Sensitivity Analysis.

This would focus on the Muscoy area, and would evaluate the sensitivity of the model to inputs as judged by the outputs in the Muscoy area, the source area, and the downgradient, potential plume barrier/extraction area.

B.2 SPECIFIC ACTIONS

Three specific observations were determined to be areas of deficiency, compared to overall project goals. Beneath each observation are listed potential causes of the deficiency, and one or more actions that can be taken to correct or improve model operation. Note that some actions will apply to the effort to improve more than one area.

OBSERVATION 1: Poor correlation between measured and predicted water levels. For a number of wells, principally in the Muscoy OU, predicted and observed water levels vary significantly.

Cause 1.1: Distribution of subarea gradients is not correct. Within the model area, there are several subareas where the predicted groundwater flow direction is different from observed flow.

Action 1.1A. Contour measured water level data and interpret it with respect to suspected model deficiencies.

Action 1.1B. Review existing data on water levels with respect to updates and special needs of the Muscoy OU.

It is expected that these actions will increase the level of confidence in all subsequent efforts to calibrate and otherwise adjust the model will be done with the most complete data set available.

Cause 1.2: Overall water budget balance is deficient. It is plausible that variable boundary influxes and surface seepage inputs, contribute to the poor correlation.

Action 1.2A. Reevaluate and modify boundary influx and surface seepage data with respect to discrete concerns identified in Task 1.4.

Action 1.2B. Modify the no-flow boundary along the San Jacinto Fault

Cause 1.3: Bedrock depth data insufficient. Within the Muscoy half of the model area there are broad areas with little constraint on the bedrock depth. This effects the aquifer storage and the flux possible through the areas.

Action 1.3A. Review existing data on bedrock depths with respect to the unique concerns of Muscoy.

Action 1.3B. Acquire additional bedrock depths from existing data, or additional boreholes, geophysical surveys or other means.

Cause 1.4: Uncertainties in boundary conditions. Surface water data for rivers and evapotranspiration have some uncertainty. However, the confidence level on the existing data is high. These will effect the overall water budget balance.

Action 1.4A. Reevaluate general near-boundary conditions.

Cause 1.5: Very limited hydrologic data exists in the area south of Shandin Hills. This geographic area is critical to the Muscoy project, and data inputs to the model are sparse here.

Action 1.5A. Review and confirm completeness of well pumpage data in the Muscoy-specific area south and southwest of Shandin Hill.

Cause 1.6: Insufficient pumpage data. Although numerous pumpage data exist and have been incorporated into the model, one or two large pumping wells in the Muscoy model area (not accounted for) could have significant impact.

Action 1.6A. Review and confirm completeness of well pumpage data in the Muscoy-specific influence area.

OBSERVATION 2: Water levels southwest of Shandin Hills (the Muscoy area) are predicted far higher than those observed. Additionally, the predicted levels do not follow the temporal trend of the observed data.

Cause 2.1: Water in-flow rate may be too high relative to the out-flow rate. The modeled in-flow may be too high, the out-flow too low, or a combination of both may exist.

Action 2.1A. Modify no-flow boundary at San Jacinto Fault. This would allow water an additional path to flow out of this area. The scale of the leakage necessary should be estimated and the hydrogeologic plausibility for this should be evaluated. Allowing flow out of the model area to the southwest would likely result in a stronger westward flow through the SWG, opposite the observed eastward flow.

Action 2.1B. Modify depth to bedrock west and south of Shandin Hills. This potentially will allow water to flow eastward (as observed, but which presently the model does not predict) between the Shandin Hills and Wiggins Hill. A concern will be to ensure that water gradients are not adversely changed in other key areas of the model.

OBSERVATION 3: Groundwater is observed to flow eastward past the north side of the Shandin Hills, within the Shandin Wiggins Gap, but the model predicts westward flow. Efforts noted above, including reevaluating the water balance and modifying bedrock topography, may provide sufficient solution.

<u>Cause 3.1</u>: There is insufficient water level data in a critical region.

Action 3.1A. Install groundwater monitoring well(s) north and northwest of the Shandin Hills. This would be desirable, as it would represent hard data (and additional chemical data as well).